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Intelligent transport systems — Performance testing for connectivity and safety functions of automated driving buses in public transport —

Part 1: General framework

Systèmes de transport intelligents - Essais de performance pour les fonctions de connectivité et de sécurité des bus à conduite automatisée dans les transports publics —

Partie 1: Cadre général

Reference number
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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

A list of all parts in the ISO 21734 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Automated vehicle technology has been developing rapidly in recent years as one of the measures for reducing automobile accidents caused by human errors and for promoting the automobile industry. The automated driving bus (ADB) is a new type of public transport mode embedded with automated vehicle technologies. The progress of the development and deployment of the ADB has been accelerated in recent years, exceeding the speed of automated passenger vehicles.

The overall purpose of this document is to provide technical standards at the international level to ensure the safety and connectivity of the ADB operating as a public transport mode. The objectives of this document include building a framework for operating ADBs in public transit networks, developing performance test methods and procedures in terms of safety and connectivity of ADBs that require communication with roadside infrastructure and with the monitoring and control centre, and providing the service framework and use cases as references for field applications.

From the connectivity perspective, the ADB needs to be connected with traffic signal networks for vehicles and pedestrians, with the monitoring and control centre for bus operation, and with other relevant infrastructure to ensure its effectiveness as a public transport mode. In terms of safety, the ADB needs to be embedded with automated vehicle functions to connect with the wireless signal control system and to be ready to respond to unexpected situations involving other road users such as pedestrians and bicyclists.

Furthermore, the authorities of public transport need technical standards to measure the performance of ADB for enhancing public safety on roads.

Therefore, this document is intended to benefit public transport operators, relevant governing authorities of public transport, and industrial stakeholders.

This document provides the basis for the development of performance testing for connectivity and safety functions of ADB on a national and international level.

Intelligent transport systems — Performance testing for connectivity and safety functions of automated driving buses in public transport —

Part 1: General framework

1 Scope

This document specifies the general framework and the automated driving bus (ADB) system components for operating ADBs in public transport networks, including:

a) the general framework and the operation scheme for public transport systems in cooperation with ADBs;

b) definitions of system components for operating ADBs; and

c) definitions of functions and requirements of each system component for providing transport services with ADBs.

This document is applicable to bodies in public transport systems and services including transportation operators, public transport governing authorities and relevant industries.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 Terms and definitions

3.1.1
automated driving bus
ADB
bus designed for public transport and embedded with automated driving functions based on SAE level 4 or higher

3.1.2
operation safety
set of minimum safety requirements ensuring an automated driving bus's expected functions as a public transport mode when operating in cooperation with road infrastructure

Note 1 to entry: Road infrastructure includes exclusive bus lanes, bus stations, signalized and non-signalized intersections, crosswalks for pedestrians and bicyclists, general traffic signals, bus priority signals, and monitoring and control centres.

3.1.3
safety function
set of minimum functions related to the safety of an automated driving bus (ADB) as a public transport mode, facilitating passengers on board, at bus stations and responding to emergency events that can arise both inside and outside of ADBs

3.1.4
connectivity of ADB
connectivity performance of an automated driving bus (ADB) system that ensures the stable and reliable provision of the information feed required to provide safe public transport services

3.1.5
transport information
set of information required for automated driving buses (ADBs) to function as a public mode

Note 1 to entry: This includes operation information exchanged between road infrastructure and ADBs themselves, bus priority signal information, passengers' boarding and alighting information, roadside signage equipment information, battery charge and discharge information (if the bus is an electric bus), etc.

3.1.6
ADB system framework
framework for ensuring stability and safety of automated driving bus system operations through interactions among automated driving bus (ADB) system components

3.1.7
ADB system components
required components for operating an automated driving bus (ADB) system

Note 1 to entry: The components include the ADB, the monitoring and control centre, Internet of Things infrastructure, smart bus stations and users.

3.1.8
ADB service framework
framework for transport services provided by the automated driving bus (ADB) system through interactions among the ADB service components, consisting of the ADB, the monitoring and control centre, passengers, smart bus stations and Internet of Things infrastructure

3.1.9
monitoring and control centre
MC centre
system that ensures the safe operation of the automated driving bus (ADB) system by monitoring and controlling the fleet through collecting data from each component (the ADB, ADB users, Internet of Things infrastructure, smart bus stations), processing the data, and providing comprehensive information to each component

3.1.10
IoT infrastructure
Internet of Things infrastructure
sensor system collecting road traffic and environment data at intersections, pedestrian crosswalks and smart bus stations

Note 1 to entry: The collected data is transmitted to the monitoring and control centre and automated driving buses (ADBs) directly through communication networks.

3.1.11
smart bus station
facility where an automated driving bus stops and passengers safely board, alight, and wait for an automated driving bus

Note 1 to entry: The smart bus station is installed with a station kiosk and Internet of Things infrastructure to communicate with the monitoring and control centre.

3.1.12
station kiosk
device that is installed at a smart bus station and assists passengers with their boarding reservations, the payments and ticketing

3.1.13
pickup station
smart bus station which is designated by the monitoring and control centre and at which it is intended that an automated driving bus (ADB) will pick up passengers when operating a demand-responsive route

3.1.14
routine station
fixed smart bus station that is designated for automated driving buses (ADBs) as a location to stop at for picking up and dropping off passengers

3.1.15
one-time boarding ticket
boarding ticket that is used for one round trip

Note 1 to entry: Depending on reservation methods, tickets can be either paper or electronic.

3.1.16
ADB users
general passengers who are the primary party receiving mobility services and legal entities providing mobility services to the passengers including local authorities and private bus operators

3.1.17
passenger
one of the automated driving bus (ADB) users receiving ADB mobility services

3.1.18
operator
one of the users who is responsible for operating and managing the automated driving bus (ADB) systems

3.1.19
operation manager
person responsible for monitoring the automated driving bus (ADB) fleet operation and responding to emergencies in the monitoring and control centre

3.1.20
in-vehicle operation manager
person responsible for monitoring automated driving bus operations and responding to emergencies in an automated driving bus (ADB) vehicle

3.1.21
on-demand route
operating measure with flexible schedule and route to respond to passengers' demands within the delineated service area

Note 1 to entry: Passengers may only board and alight at a smart bus station.

Note 2 to entry: An automated driving bus (ADB) can deviate from a fixed route to an on-demand route in response to the passengers' demand. However, the automated driving bus should stop at a smart bus station.

3.1.22
automated driving message
ADM
message carrying data collected by a suite of automated driving bus (ADB) sensors

Note 1 to entry: The types of messages and the data each message includes are as follows:

— ADB driving messages include speed, acceleration and deceleration, angular acceleration, etc.

— ADB positioning messages include latitude, longitude, global navigation satellite system mode, etc.

— Route messages include a route ID, stopovers, the destination, etc.

— Route following messages include orientation control, control speed, acceleration, brake, mission, etc.

— Object messages include object type, distance to object, etc.

— Decision messages include system decision messages such as departure, stop, waiting, transmission information, etc.

— Sensor messages include fail or safe, rerun message, etc.

— Automated driving status messages include fail or safe, passenger information, etc.

3.1.23
automated driving service message
ASM
service message such as automated driving control, road driving and pedestrian protection, and the collected information which includes service unique ID, service purpose and service provision location, etc.

3.1.24
basic safety message
BSM
message providing basic information for safe driving such as communication status, weather information, system status, etc.

3.1.25
emergency event message
EEM
message providing information for responding to the vehicle emergency and driving requirements when operating

Note 1 to entry: The collected information includes emergency event ID, location, time of the emergency, etc.

3.1.26
routine data set
data set that the two components (automated driving bus and monitoring and control centre) regularly exchange without a request from each side

3.1.27
event data set
data set provided when requested by automated driving buses (ADBs) or the monitoring and control centre

3.1.28
backup data set
data sets stored once the automated driving buses (ADBs) finish one round of the route

3.1.29
target location
specific point on an automated driving bus route where an automated driving bus is aiming to move on

3.1.30
target vehicle
vehicle that can form a conflict with an automated driving bus by driving in opposite directions or merging into the same lane, at the same location, and at the same time

3.1.31
target object
pedestrian, bicycle rider and other non-human object that can potentially form a conflict with an automated driving bus (ADB)

3.2 Abbreviated terms

BIS	bus information system
BMS	bus management system
BRT	bus rapid transit
DSRC	dedicated short range communication
GNSS	global navigation satellite system
IoT	Internet of Things
LTE	long term evolution
RSE	roadside equipment
RSU	roadside unit
SOH	state of health for electric vehicle battery
TOD	transport-oriented development
V2I	vehicle to infrastructure
V2X	vehicle to everything
WAVE	wireless access for vehicle environment

4 General information

4.1 ISO 21734 series overview and structure

The ISO 21734 series specifies documents and standards related to the connectivity and safety functions required to support the implementation of the ADB system in the public transport network. Unlike autonomous driving vehicles which make operation manoeuvres based on their own sensor data, ADBs are connected with the MC centre and Internet of Things (IoT) infrastructure for obtaining information that is critical for ensuring safety but undetectable by their own sensors.

This document (ISO 21734-1) defines five components of the ADB system that are required for safe operations, the objectives and scopes of performance tests in terms of connectivity and safety for ADB operations, and service framework and use cases.

ISO 21734-2:—[1)] specifies the performance requirements and test procedures for ADBs to operate in existing public transport systems. It specifies appropriate types of test methods and performance standards to ensure the overall safety of public transport operations.

ISO/TR 21734-3:—[2)] specifies the service framework and uses cases as a technical reference for field applications. The service framework is composed of software that utilizes components of ADBs,

1) Under preparation. Stage at the time of publication: ISO/AWI 21734-2:2022.

2) Under preparation. Stage at the time of publication ISO/DTR 21734-3:2022.

passengers, IoT infrastructure, smart bus stations, the MC centre and other elements for serving passengers.

4.2 Purpose of the ISO 21734 series

The overall purpose of ISO 21734 series is to set performance standards, testing methods and procedures for operating ADBs when adopted for a conventional bus system.

The purpose of ISO 21734–1 (this document) is to provide general information on the ISO 21734 series, including the basic structure of the series. It further specifies five ADB system components that are required for ADBs to operate in existing bus system and use cases.

The purpose of ISO 21734-2 is to specify performance requirements to be adopted safely as an ADB system in terms of safety and connectivity and to specify test procedures for ensuring safety and connectivity of the ADB system operation.

The purpose of ISO 21734-3 is to specify the ADB system service framework and use cases as a reference for application.

5 ADB system Components

5.1 Overview

The ADB system shall consist of five components as shown in Figure 1: ADBs, the MC centre, IoT Infrastructure, smart bus stations and ADB users.

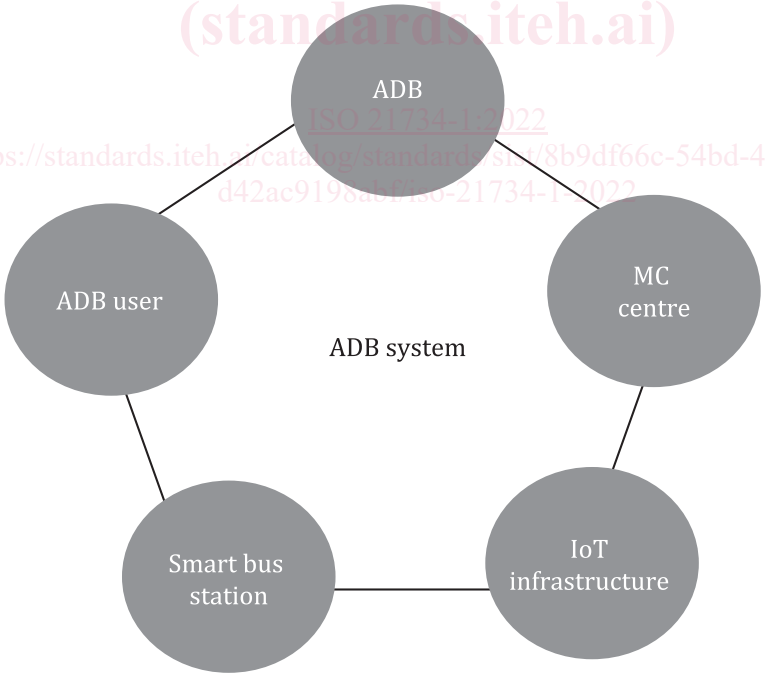

Figure 1 — Five components of ADB system

5.2 ADB component

The ADB component is the most important component; all others except ADB user are supporting the safe driving of ADBs. An ADB vehicle shall be designed for carriage of passengers with capacity of more than nine persons and shall be embedded with level 4 automated vehicle technologies or higher based on SAE J3016.

The ADB shall be capable of operating on fixed and on-demand routes, communicating with the MC centre and IoT infrastructure, detecting traffic signals and other objects that may deter its safe operation, allowing passengers to board and alight at a smart bus station regardless of the existence of a driver on the ADB, along with emergency response features.

5.3 MC centre component

The MC centre is specified as a system that ensures the safe operation of the ADB system by monitoring and controlling the fleet. This is achieved by collecting data from each component (ADB, ADB users, IoT infrastructure and smart bus station), processing the data, and providing comprehensive information back to each component.

From the controlling perspective, the MC centre shall be equipped with a bus information system (BIS) and a bus management system (BMS) that collect real time bus operation data at smart bus stations and provide bus information to the passengers. The real time bus information data includes traffic signal information, fleet and fare management information and passenger information.

From the monitoring perspective, the ADB system is required to manage not only bus schedules but also payments, passenger boarding and alighting and emergency responses. For responding to emergency events, an ADB system is required to control the site both inside and outside of the vehicle by connecting emergency first responders including medical centres, police office and fire stations.

Therefore, the MC centre shall be able to collect data from and provide information back to ADBs, ADB users, smart bus stations and IoT infrastructure through communication networks.

5.4 IoT infrastructure component

The IoT infrastructure is specified as a complementary system that enhances safe operation of ADBs. It is installed on roadside infrastructure and facilities for collecting relevant environment data including road, traffic, and weather conditions through direct sensing and being fed from other components. The data collected by the IoT infrastructure is then provided to ADBs and the MC centre (if necessary).

IoT infrastructure shall be able to update information on ADB operation and the relevant surroundings in real time.

5.5 Smart bus station component

The smart bus station is specified as a physical space with relevant systems that enable passengers to board and alight to ADBs and enhance passenger services. It shall be able to allow passengers to get on board and alight an ADB at a smart bus station they planned for and provide arrival and departure information.

With the ADB system, the bus station shall be able to provide passenger information including a count of how many passengers expressed their intention to board a specific ADB at a specific station, fare and payment as they expressed their intention to board, etc. It also serves to provide ADBs with road traffic conditions as supplementary information when making decisions for departure from the station and merging into the main lane, as well as managing stop lots by assigning a proper lot to a specific ADB if necessary. To carry out such functions, the smart bus station shall be equipped with the stop sign, passenger facilities, and a device that receives and presents bus information, as well as sensor devices to detect road traffic conditions and kiosk devices for allowing passengers to express their intention to board an ADB and to collect their fares.

5.6 ADB user component

The ADB user is specified as general passengers who are the primary party receiving mobility services and legal entities providing mobility services to the passengers including local authorities and private bus operators.